



GENERAL MAGNETICS, INC.

M A G N E T I C M O D U L A T O R S A N D C O N T R O L S Y S T E M S

135 BLOOMFIELD AVENUE • BLOOMFIELD, N. J.

TEL. PILGRIM 8-2400

Mr. T. Nelson
Box 1546
Poughkeepsie, N. Y.

Gentlemen:

Thank you for your recent inquiry regarding our Magnetic Modulators, We are enclosing a number of bulletins describing some of our most widely used components.

All electrical parameters and impedance levels may be varied in an infinite number of ways to precisely incorporate the Magnetic Modulator function into any control circuit mode of operation. Any number of isolated control signal inputs may be easily provided for multiple data conversion. Any number of output circuits or taps may be provided for driving vacuum tube, transistor or additional magnetic stages as the case might be. Should an application for a "Mag Mod" arise we would appreciate your phoning or writing us regarding the most suitable Modulator for your particular circuit configuration. In most cases there is no extra cost for sample units specifically designed to meet your precise specifications.

The cost of the Magnetic Modulators, in sample lots of 1-24 pieces, ranges from \$120.00 to \$175.00 each, delivery as required. The sample price for multiplying modulators is slightly higher, with the cost differential being a function of the degree of linearity and product accuracy required of the Multiplier.

Very truly yours,

GENERAL MAGNETICS, INC.

M. G. Tekosky
Vice-President

"MAG - MOD"
MAGNETIC

M O D U L A T O R S • M U L T I P L Y I N G M O D U L A T O R S • C O N V E R T E R S

THE CIRCUIT AND FUNDAMENTAL PRINCIPLES OF THESE MAGNETIC MODULATORS AND MULTIPLIERS ARE COVERED BY U.S. PATENT #2758162

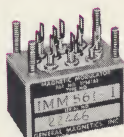
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Micro Magnetic Modulators*



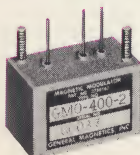
Miniaturized Magnetic Modulators*



Standard Magnetic Modulators*



Miniaturized Multiplying Modulators*



Miniaturized High-stability Oscillators*

There is
no substitute
for
reliability

"MAG MOD"

A Prime Component in Solid State Electronics



* Products shown approximately one-half actual size

"MAG MOD" MAGNETIC MODULATORS

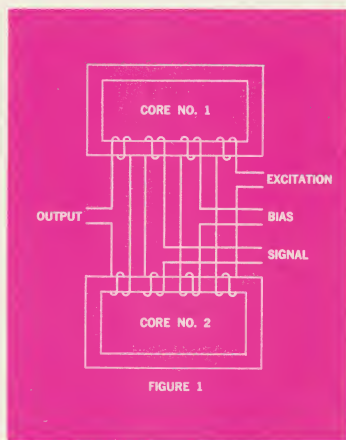


FIGURE 1

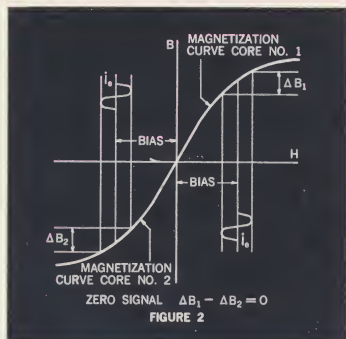


FIGURE 2

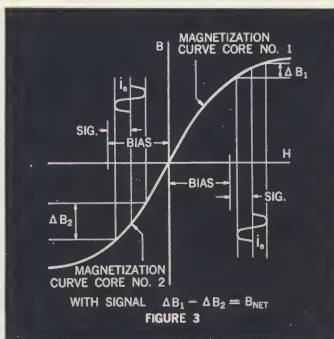


FIGURE 3

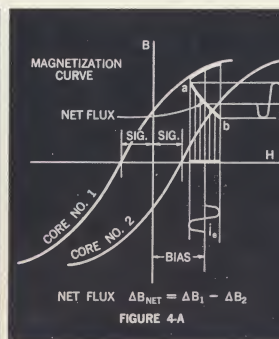


FIGURE 4-A

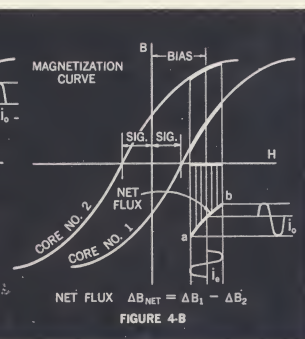


FIGURE 4-B

HOW IT FUNCTIONS -

The Magnetic Modulator consists of two permeable cores. (See Fig. 1). On each core there is an excitation, bias, signal and output winding. Each of the related windings is connected in series and brought to the outside. In this way, the current in both excitation windings, for instance, will be equal. The same is true of the currents in the other windings. Both cores are of the same material and are carefully matched to have the same magnetic characteristics. (See Fig. 2). The bias winding provides constant flux in each core, and excitation current causes a flux variation proportional to excitation current. Therefore, both cores are operating about the same point on their respective magnetization curves and have flux variations which are equal at all times (i.e., $\Delta B_1 = \Delta B_2$ or zero, and the output is zero). The net flux which links with the output windings will be $\Delta B_1 - \Delta B_2 = 0$, and the output is zero.

The signal winding is wound so that its ampere-turns oppose the ampere-turns of the bias winding in one core and aid the ampere-turns of the bias winding in the other core. When a signal is imposed, one core moves further into saturation, and the other moves out of saturation. (See Fig. 3). Because we are now operating at different portions of the two curves, ΔB_1 will be less than ΔB_2 and there will be a net flux linking with the output winding, giving us an output of the same frequency as the excitation by transformer action.

In Figure 4 (a) and (b), instead of showing the magnetization curves as mirror images of each other, we plot them both on the upper axis, and represent the action of the signal ampere-turns by shifting the magnetization curves along the H axis away from each other. i_o is the current in the excitation winding and i_b is the output current. In Figure 4 (a) the signal is positive so that its effect is as shown.

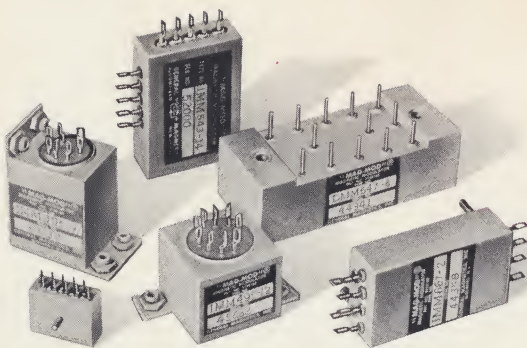
In Figure 4 (b) the signal is negative and has the opposite effect. The magnetization curves are shifted the same amount in each case, but the shift direction is changed. Since our net flux $\Delta B_{net} = \Delta B_1 - \Delta B_2$, it follows that the net flux suffers a space phase reversal when the input signal polarity is changed and, therefore, the output suffers a 180° time phase reversal.

Linearity: If the curve of net flux B_{net} vs. H (ab in Fig. 4) were linear, then the output would be linear; that is, it would be a reproduction of the input.

There are two methods by which linearity may be obtained. The first is to use core materials which have magnetization curves which approach a logarithmic form. If the curves are logarithmic, they can have equal curvature and, therefore, their difference (B_{net}) will have a constant slope. Modern core materials approach this condition. The second method is to load the output comparatively heavily. This action can best be explained by considering the case in which a direct short is placed across the output. Ordinarily the excitation builds up a net flux in the core, and the output voltage is proportional to the time rate of change of flux. In this case, with a short circuit across the output, there is no output voltage. Therefore, there can be no net flux. This condition is maintained because an output current flows of such a nature that its self-induced flux is equal and opposite to the net excitation flux at all times. Here we have two equal and opposite fluxes which are proportional to the currents causing them, therefore, the output current wave form is a reproduction of the excitation current wave form, and linearity is obtained. The combination of these two methods gives us an amplifier whose output is sinusoidal and whose gain is constant over its working range.

Designed to Provide
Absolute Dependability
and Repeatability
during Years of Standby
and Operating Life

PARABOLIC
PARABOLIC



"MAG MOD" MAGNETIC MODULATORS



General Magnetics maintains extensive laboratory facilities for research and development



The Engineering Department is prepared to customize designs for special requirements

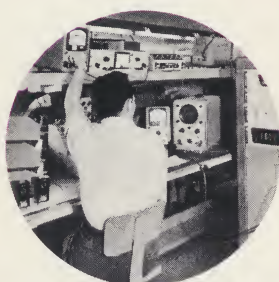
The "MAG MOD" has proven to be the most reliable module circuit block in aircraft and space vehicle flight control systems developed to date. Its ruggedness, dependability, repeatability, universal energy and impedance ranges and superior performance have resulted in its use in many military and commercial products where reliability is a prime factor.

Typical of the applications where the "MAG MOD" is utilized are missile, satellite and aircraft control and position circuits, fire control and bombing computers, analog circuit functions, antenna position data conversion, and an infinite variety of conversion, computing and modulation operations.



All phases of production are carefully controlled to insure strict adherence to quality standards

ALL "MAG MODS" CONFORM TO MIL-T-27A AND MIL-E-5400 SPECIFICATIONS



New products are subjected to exhaustive electrical and environmental testing

Bulletins available on "MAG MOD" components include Micro-circuit Magnetic Modulators Bulletin MM 101, Standard Magnetic Modulators Bulletin MM 103, Miniaturized Multiplying Modulators Bulletin MM 104, and Miniaturized High-stability Oscillators Bulletin MM 105.

Custom Requirements — Customized application engineering, whenever required, will be performed on a no charge basis, please send drawings or detailed specifications with inquiries.

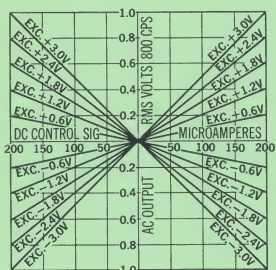
GENERAL MAGNETICS • INC



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BLOOMFIELD, NEW JERSEY, U.S.A.

General Magnetics

MAGNETIC MODULATORS



The magnetic modulator is a completely solid state device capable in itself, without the aid of diodes or other elements, of performing the analog functions of addition, subtraction and multi-

plication. The transfer function of the modulator may be expressed by the following equation:

$$E_o = K \text{ Exc } I \text{ sig.}$$

$I \text{ sig.}$ = D.C. control current usually in the microampere range.

Exc = A.C. carrier or excitation voltage.

K = Constant associated with a particular type of modulator.

The output characteristics of a typical multiplying modulator are shown in the accompany-

ing figure. It can be seen from the characteristic that the particular unit is capable of a sensitivity of 5 volts per milliampere at 3 volts excitation. This is far superior to the sensitivity demonstrated by other solid state devices such as Hall generators and magneto-resistance multipliers. The modulator is also free from the impedance problems present with these devices as it may easily exhibit impedances greater than 10 K on its input windings. Thus, this device is capable of giving high sensitivity, high impedance and clean sinusoidal output all in volumes approaching 0.2 cubic inches. While the modulator is often considered in connection with analog computation problems in computer applications, there are many other areas where it has proved useful. In order to acquaint you with some of these possibilities, we have listed the typical ones below:

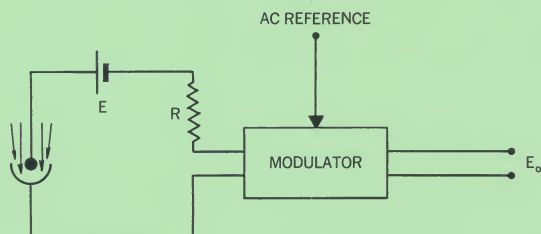


Figure 1—Photo Sensing

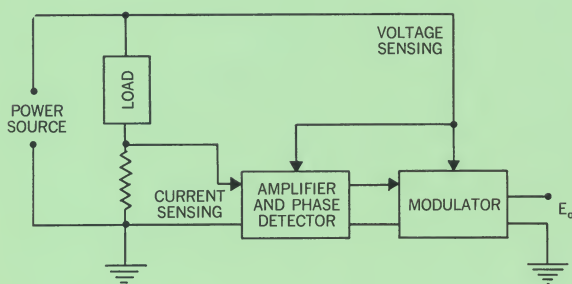


Figure 2—Power Measurement

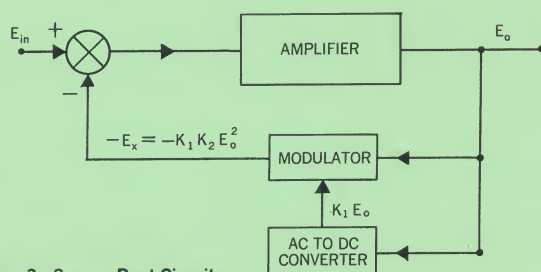


Figure 3—Square Root Circuits

Photo Sensing:

Since the modulator is very sensitive to D.C. signals in the nanoampere region it is an ideal device for detecting and amplifying weak signals from photo tubes.

Power Measurement:

Since the output of the modulator is proportional to the product of its two signals, it may be used in power or voltampere measurements. In the circuit shown, actual power is measured as only the in-phase portion of the current signal reaches the modulator. If simple volt-ampere measurements are desired, the phase detector is omitted.

Square Root Circuits:

The modulator, when used in conjunction with an operational amplifier, may be employed in systems designed to give an output proportional to the square root of the input. If K_1 is the transfer function of the converter and K_2 is the transfer function of the modulator, the summing point voltage will be

$$E_{in} - K_1 K_2 E_o^2 = \frac{E_o}{A}$$

For normal values of amplifier gain this error voltage will be negligible so that we may say

$$E_{in} = K_1 K_2 E_o^2 \quad E_o = \sqrt{E_{in}/K_1 K_2} \quad E_o \approx \sqrt{E_{in}}$$

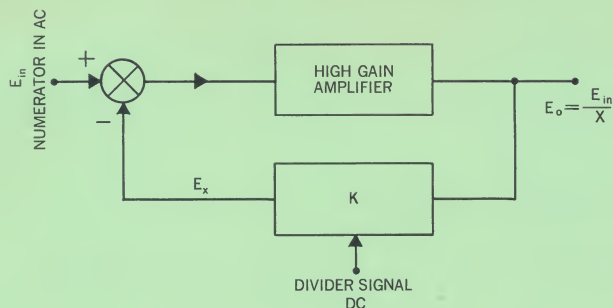


Figure 4 - Division Circuits

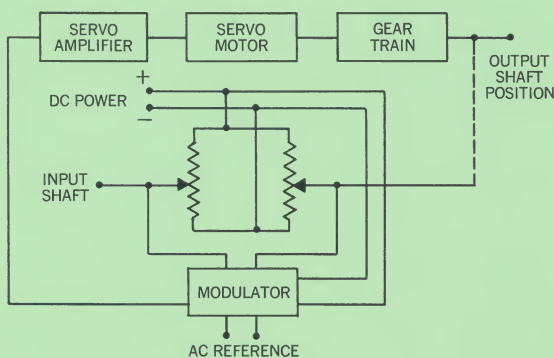


Figure 5 - Hybrid Position Servos

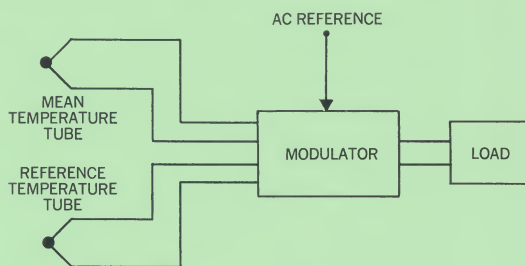


Figure 6 - Temperature Sensing

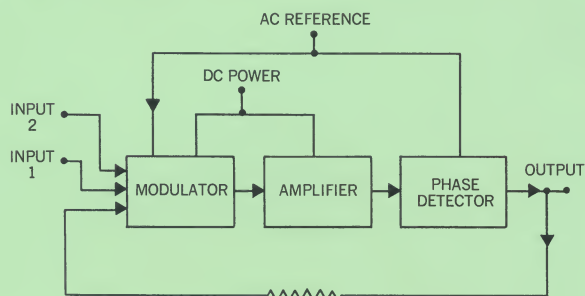


Figure 7 - DC Amplifier Applications

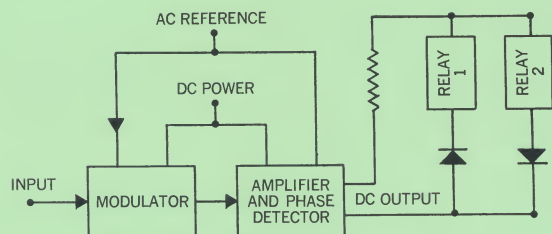


Figure 8 - Phase Sensitive Relay

Division Circuits:

The modulator may be used in conjunction with an operational amplifier to give an output which is proportional to the quotient of two signals. If K is the transfer function of the modulator, the error point voltage will be

$$E_{in} - KE_oX = E_o/A$$

For large A we have

$$E_{in} = KE_oX$$

OR

$$E_o = \frac{E_{in}}{KX}$$

$$E_o \approx E_{in}/X$$

Hybrid Position Servos:

In this circuit the output shaft position is aligned with the input shaft position. The potentiometers are excited by a D.C. voltage. The error signal is converted to proportional A.C. in the modulator, pre-amplified and fed to the servo-motor which aligns the output shaft position until the error signal goes to zero.

Temperature Sensing:

In this system the modulator signal windings oppose each other to give zero output when the two thermocouple signals are equal. The magnitude of the output will be proportional to the temperature difference while its phase will indicate the direction of the difference. This output may then be fed back thru an appropriate servo system to control the temperature being measured.

D.C. Amplifier Applications:

The modulator is far superior to a chopper in D.C. amplifier applications. It offers complete isolation of the input signal from ground or from other signals. Differential inputs are easily accommodated thru the use of separate, opposed signal windings. The feedback signal, due to the presence of the phase detector, will always be in-phase opposition to the net modulator input, thus giving the system exceptional stability. D.C. feedback also minimizes phase shift problems normally associated with amplifiers of this type. The bandwidth of the amplifier will approach approximately 40% of the reference frequency.

Phase Sensitive Relay:

Use of the modulator in a system like this enables the designer to selectively operate relays depending on the phase of the input signal.

CALL OR WRITE FOR FURTHER INFORMATION ON SPECIFIC APPLICATIONS

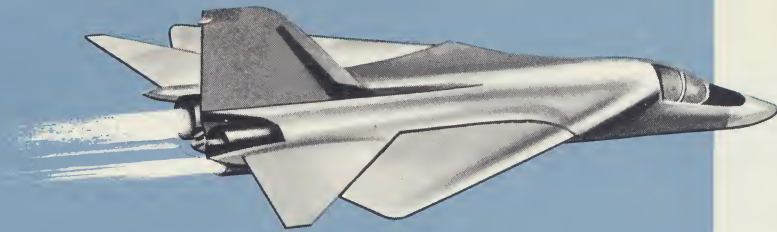


GENERAL MAGNETICS-INC

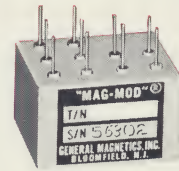
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Litho in U.S.A.

THERE IS NO SUBSTITUTE FOR RELIABILITY



**WORLD'S
SMALLEST
and
MOST
RELIABLE!**



**Monolithic Analog
Computing Modules...**

**G/M Analog
Voltage
Multiplier**

New Micro-miniature G/M
Analog Voltage Multiplier
measures only 0.1 cubic
inch, weighs but 0.1 ounce.



"MAG MOD"®

Micro Magnetic Multiplying and Dividing Modulators*



THERE IS NO SUBSTITUTE
FOR RELIABILITY!

*CIRCUIT COVERED BY U.S.
PATENT NO. 2758162

MONOLITHIC MICRO CIRCUIT BLOCK for analog voltage multiplying
of D.C. and A.C. voltages.

ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION of many
voltage variables may be handled by one G/M Magnetic Microblock.

PRODUCT ACCURACY of up to 0.2% of full scale, with very slight
derating over a wide temperature range.

FOR ADDITIONAL DATA AND SPECIFICATIONS REFER TO REVERSE SIDE

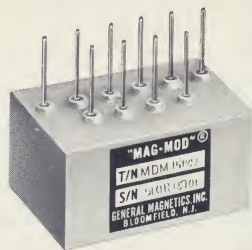
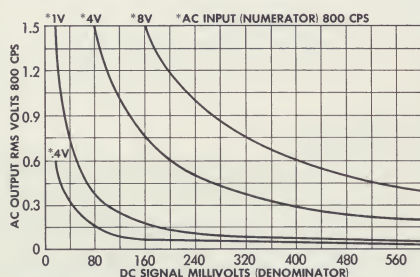
...THE LATEST ADVANCE IN

Micro Miniaturization

**G/M
SOLID
STATE**

MAGNETIC DIVISION MODULES

Completely solid state modules that perform analog division, provide accuracy of 1% or better over numerator and denominator ranges of 20 to 1. Numerator consists of an A.C. input signal; denominator is a D.C. control signal. These modules make it possible to avoid complex, cumbersome circuitry formerly used in solving analog equations, and in trig function conversion. Features include the high reliability of magnetic devices, adaptability to any signal frequency from 60 cps to over 100 kc, operation over wide ambient ranges and in severe environments. Small size is ideal for printed circuits.



GENERAL MAGNETICS

MICRO MAGNETIC MULTIPLYING MODULATORS

- Absolute reliability—unlimited life
- Extreme stability with negligible change of product accuracy over a wide temperature range
- High shock and vibration proof
- Bandwidth may be extended for the kilocycle range
- Low milliwatt power consumption
- Four quadrant operation
- Repeatable data over years of continuous, unattended operation
- Simple, lightweight, rugged
- May be mounted directly on printed circuit cards

SPECIFY "MAG MOD" for proven reliability in solid state amplitude module applications. These dependable instruments are widely employed in flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas and thousands of control systems. Micro-circuit, miniature, subminiature, standard and specials available.

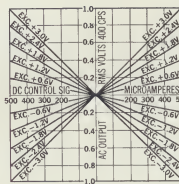
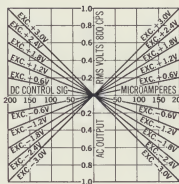
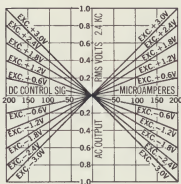
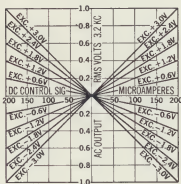
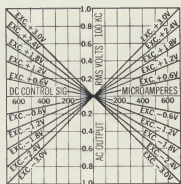
CUSTOM REQUIREMENTS—Customized application engineering, when required, will be performed on a no-charge basis.

CIRCUIT AND PRINCIPLES OF G/M MAGNETIC MULTIPLIERS COVERED BY U.S. PATENT NO. 2758162

TYPE NUMBER	MCM-827-2	MCM-836-1	MCM-845-1	MCM-847-1	MCM-848-1
Accuracy (% Error of Theoretical Prod.)	1% Maximum	Approx. 0.5%	Less than 1%	2% Maximum	5%
Input Control Signal Range	0 to $\pm 800 \mu\text{A}$ (DC to 5,000 cps)	0 to $\pm 200 \mu\text{A}$ (DC to 200 cps)	0 to $\pm 200 \mu\text{A}$ (DC to 100 cps)	0 to $\pm 200 \mu\text{A}$ (DC to 50 cps)	0 to $\pm 500 \mu\text{A}$ (DC to 40 cps)
DC Resistance of Input Signal Range	500 ohms	12.5 K ohms	12.5 K ohms	12.5 K ohms	70 K ohms
Input AC Sig. Range Amplitude, Freq.	0.6 V to 3 V RMS Phase Rev. 100 KC	0 to 3 V RMS Phase Rev. 3200 cps	0 to 3 V RMS Phase Rev. 2400 cps	0 to 3 V RMS Phase Rev. 800 cps	0 to 3 V RMS Phase Rev. 400 cps
AC Output Product Range	0 to 1 V RMS @ 100KC	0 to 1 V RMS @ 3.2 KC	0 to 1 V RMS @ 2.4 KC	0 to 1 V RMS @ 800 CPS	0 to 1 V RMS @ 400 CPS
Null at Max. AC Signal, Zero DC Sig.	15 mv RMS	10 mv RMS Max.	10 mv RMS Max.	10 mv RMS Max.	5 mv RMS Max.
Output Impedance	650 ohms	13 K ohms	12 K ohms	8 to 10 K ohms	15 K ohms
External Load	10 K to 100 K ohms	50 K ohms	50 K ohms	50 K ohms	50 K ohms
Temperature Range	-55°C to +85°C	-55°C to +100°C	-55°C to +100°C	-55°C to +100°C	-55°C to +100°C
Null Drift over Temp. Range	0.1% of f.s.	0.1%	0.1%	0.1%	$\pm 0.2\%$
Accuracy Variation over Temp. Range	$\pm 0.5\%$	$\pm 0.2\%$	$\pm 0.2\%$	$\pm 0.2\%$	1%
Hysteresis in % of Max. Input DC Sig.	0.1%	0.1%	0.1%	0.1%	0.25%
% Harmonic Dist. in Output Prod. Wave	Less than 5%	3%	3% to 5%	5% Maximum	5%
Overall Dimensions (in Inches)	$\frac{5}{8} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{3}{64} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{3}{64} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{3}{64} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{3}{64} \times \frac{25}{32} \times \frac{1}{2}$
Approximate Weight (in Ounces)	0.26 oz.	0.26 oz.	0.26 oz.	0.26 oz.	0.26 oz.

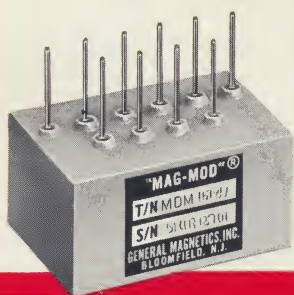
OTHER G/M COMPONENTS

Also available is a complete line of magnetic modulators, magnetic multiplying modulators, high stability oscillators and relays. Write today for bulletins MM 101 Series Micro Magnetic Modulators, MM 102 Miniaturized Magnetic Modulators, MM 103 Standard Magnetic Modulators, MM 104 Miniaturized Multiplying Modulators, MM 105 Miniaturized High-stability Oscillators, MM 106 Micro Magnetic Multiplying Modulators, MM 107 Magnetic Relays and MM 108 Solid State Magnetic Demodulators.



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135 BLOOMFIELD AVENUE, BLOOMFIELD, NEW JERSEY 07003

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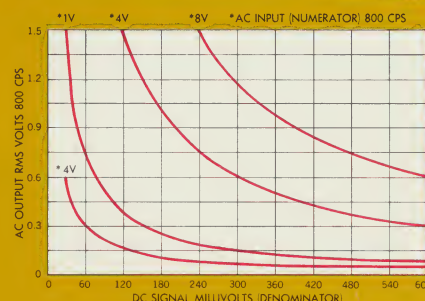
G/M Micro-Miniature
Division Module
Shown Actual Size

THE NEW DESIGN CONCEPT!
Highest Reliability with Absolute Accuracy
of 1% or Better over Wide
Environmental Ranges.



Circuit covered by U.S.
Patent No. 2758162
Additional Patent Pending

Micro-Miniature SOLID STATE Magnetic Division Modules



There is No Substitute for Reliability—

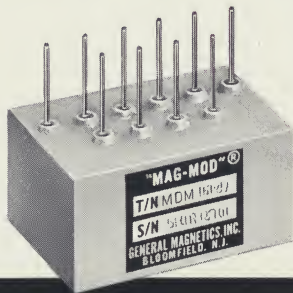
G/M Analog Division Modules employ a new concept which does away with high gain operational amplifiers and logarithmic circuitry previously used in electronic dividers. Elimination of these amplifiers means fewer components resulting in higher reliability, excellent stability, micro-miniature size and lower cost. The combination of magnetic and semiconductor circuitry results in analog division with absolute accuracies of 1% (.1% full scale) or better over wide environmental ranges. The output is an A.C. sinusoidal signal which is the quotient of an A.C. numerator and a D.C. denominator.

These modules can be engineered to meet your most exacting requirements. Small physical size makes the new modules ideally suited for printed circuit use. If your problem is linear division, trig function conversion, automatic gain control combined with micro-miniature size, G/M Division Modules will solve it!



FOR ADDITIONAL DATA AND SPECIFICATIONS REFER TO REVERSE SIDE

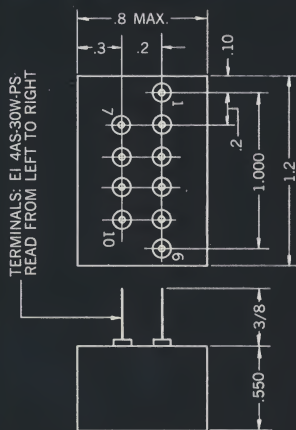
GENERAL MAGNETICS SOLID STATE **MICRO-MINIATURE** Analog Division Modules



...COMPLETELY SOLID STATE
...ABSOLUTE ACCURACY

These new modules provide the quotient of two signals; an A.C. numerator of variable magnitude and phase, and a variable D.C. denominator. They operate at frequencies as high as 100 kc and as low as 60 cps while having an accuracy of 1% absolute.

- MICRO SIZE—COMPLETELY SOLID STATE
- 1% ABSOLUTE ACCURACY (0.1% of full scale)
- LOW POWER CONSUMPTION
- NO OPERATIONAL AMPLIFIERS
- WIDE NUMERATOR AND DENOMINATOR RANGES OF 30 OR 40 TO 1
- ISOLATED INPUTS
- LOW OUTPUT IMPEDANCE
- OPERATION OVER WIDE ENVIRONMENTAL RANGES
- FREQUENCIES FROM 60 CPS TO 100 KC



Specifications for TYPE MDM 889-1*

EXCITATION
(NUMERATOR):
0.4 V. to 8 V. @ 800 cps

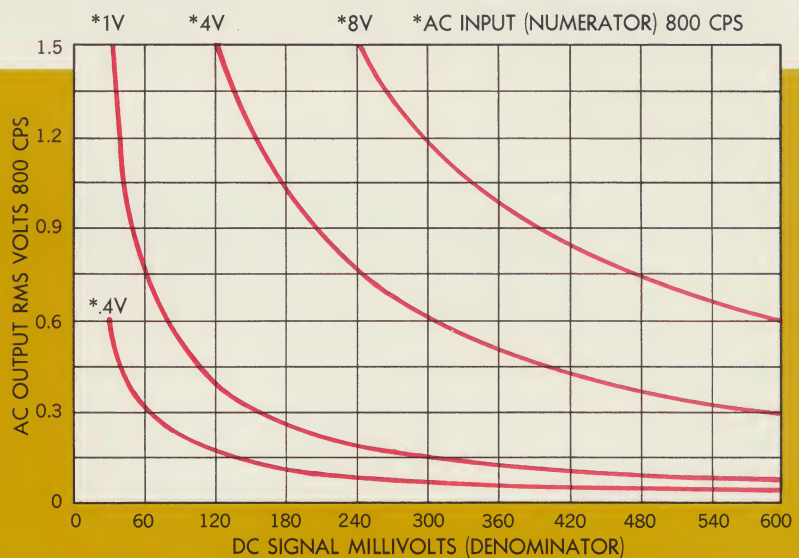
BIAS: +30 V. D.C.

OUTPUT LOAD: 5 k

SIGNAL
(DENOMINATOR):
30 mv. to 600 mv.

AMBIENT
TEMPERATURE RANGE:
0°C to +70°C

*Above specifications apply only to MDM 889-1 and may be changed to fit your exact requirements.



OTHER G/M COMPONENTS: Also available is a complete line of magnetic modulators, magnetic multiplying modulators, high stability oscillators, square root extractors and relays. Order by bulletin numbers MM 101 Series Micro Magnetic Modulators, MM 102 Miniaturized Magnetic Modulators, MM 103 Standard Magnetic Modulators, MM 104 Miniaturized Multiplying Modulators, MM 105 Miniaturized High-stability Oscillators, MM 106 Micro Magnetic Multiplying Modulators, MM 107 Magnetic Relays, MM 108 Solid State Magnetic Demodulators and MM 109 Analog Voltage Multipliers.

GENERAL MAGNETICS • INC

135 BLOOMFIELD AVENUE, BLOOMFIELD, NEW JERSEY 07003



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**ANALOG
VOLTAGE
MULTIPLIERS**



SIZE - 0.1 CU. IN. / WEIGHT - 0.1 OZ.

"MAG MOD"®

***micro* MAGNETIC MULTIPLYING MODULATORS**

- ◊ A Monolithic Micro Circuit Block for analog voltage Multiplying of D. C. and A. C. voltages.
- ◊ Addition, Subtraction and Multiplication of many voltage variables may be handled by one single Magnetic Microblock.
- ◊ **Product Accuracy:** Up to 0.2% of full scale with very slight derating over wide temperature range.

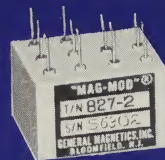


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no substitute
for
reliability

ELECTRICAL AND MECHANICAL SPECIFICATIONS FOR

- Absolute reliability • Unlimited life • Repeatable data over years of continuous, unattended operation • High shock and vibration proof • Low milliwatt power consumption • Bandwidth may be extended for the kilocycle range • Four quadrant operation • Extreme stability with negligible change of product accuracy over a wide temperature range • Simple, lightweight, rugged • May be mounted directly on printed circuit cards.

Type MCM 827-2
shown same size



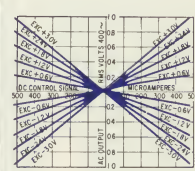
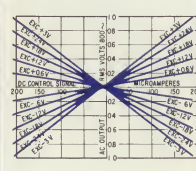
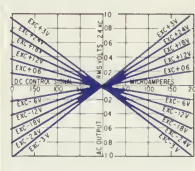
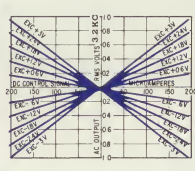
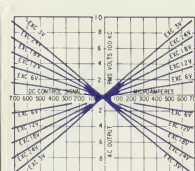
micro

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Micro Miniaturization!

GENERAL MAGNETICS

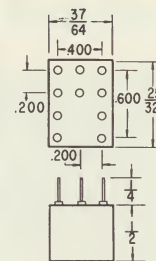
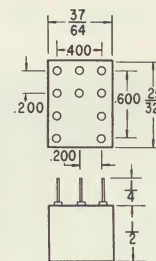
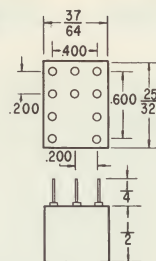
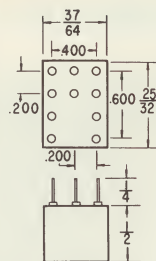
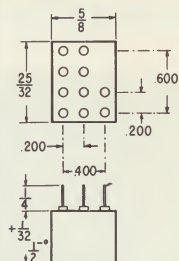
magnetic multiplying modulators

CUSTOM REQUIREMENTS—Customized application engineering, whenever required, will be performed on a no charge basis.



TYPE NUMBER	MCM-827-2	MCM-836-1	MCM-845-1	MCM-847-1	MCM-848-1
Prod. Accuracy (% Error of Theoretical Prod.)	1% Maximum	Approx. 0.5%	Less than 1%	2% Maximum	5%
Input Control Signal Range	0 to $\pm 800 \mu\text{A}$ (DC to 5,000 cps)	0 to $\pm 200 \mu\text{A}$ (DC to 200 cps)	0 to $\pm 200 \mu\text{A}$ (DC to 100 cps)	0 to $\pm 200 \mu\text{A}$ (0 to 50 cps)	0 to $\pm 15 \mu\text{A}$ (DC to 40 cps)
DC Resistance of Input Signal Range	500 ohms	12.5 K ohms	12.5 K ohms	12.5 K ohms	70 K ohms
Input AC Signal Range Amplitude and Freq.	0.6 V to 3 V RMS Phase Rev. 100 KC	0 to 3 V RMS Phase Rev. 3200 cps	0 to 3 V RMS Phase Rev. 2400 cps	0 to 3 V RMS Phase Rev. 800 cps	0 to 3 V RMS Phase Rev. 400 cps
AC Output Product Range	0 to 1 V RMS @ 5 KC	0 to 1 V RMS @ 3.2 KC	0 to 1 V RMS @ 2.4 KC	0 to 1 V RMS @ 800 CPS	0 to 1 V RMS @ 400 CPS
Null at Max. AC Signal and Zero DC Signal	15 mv RMS	10 mv RMS Max.	10 mv RMS Max.	10 mv RMS Max.	5 mv RMS Max.
Output Impedance	650 ohms	13 K ohms	12 K ohms	8 to 10 K ohms	15 K ohms
External Load	10K to 100 K ohms	50 K ohms	50 K ohms	50 K ohms	50 K ohms
Temperature Range	-55°C to $+85^\circ\text{C}$	-55°C to $+100^\circ\text{C}$	-55°C to $+160^\circ\text{C}$	-55°C to $+100^\circ\text{C}$	-55°C to $+100^\circ\text{C}$
Null Drift over Temp. Range	0.1% of f.s.	0.1%	0.1%	0.1%	0.2%
Variation of Prod. Accuracy over Temp. Range	$\pm 0.5\%$	$\pm 0.2\%$	$\pm 0.2\%$	$\pm 0.2\%$	1%
Hysteresis in % of Max. Input DC Signal	0.1%	0.1%	0.1%	0.1%	0.25%
% Harmonic Dist. in Output Product Wave	Less than 5%	3%	3% to 5%	5% Maximum	5%
Overall Dimensions (in Inches)	$\frac{5}{8} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{37}{64} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{37}{64} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{37}{64} \times \frac{25}{32} \times \frac{1}{2}$	$\frac{37}{64} \times \frac{25}{32} \times \frac{1}{2}$
Approximate Weight (in Ounces)	0.26 oz.	0.26 oz.	0.26 oz.	0.26 oz.	0.26 oz.

Specify "MAG MOD" for proven reliability in solid state amplitude modulator applications. These dependable instruments are widely employed in flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas and thousands of control systems. Micro-circuit, miniature, subminiature, standard, specials available.



Also available from G/M a complete line of magnetic modulators, magnetic multiplying modulators and high stability oscillators and solid state relays. Order by bulletin numbers **MM 101** Series Micro Magnetic Modulators, **MM 102** Miniaturized Magnetic Modulators, **MM 103** Standard Magnetic Modulators, **MM 104** Miniaturized Multiplying Modulators, **MM 105** Miniaturized High-stability Oscillators, **MM 107** Solid State Magnetic Relays.

*The circuit and fundamental principles of these magnetic multipliers are covered by U.S. Patent #2758162.

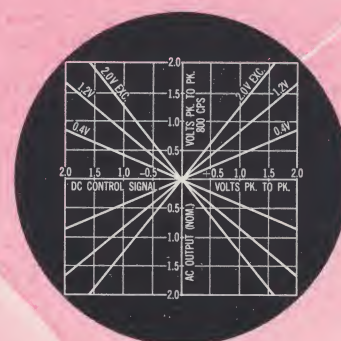
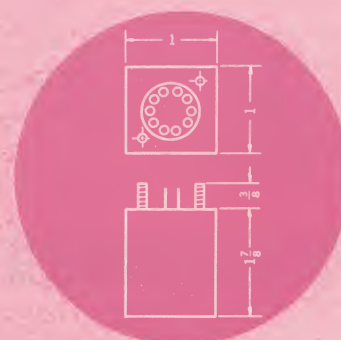


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"MAG MOD"[®] miniaturized



MULTIPLYING MODULATORS

Featuring Absolute Reliability over unlimited life with repeatable data for years of continuous, unattended operation. There are no vacuum tubes, semiconductors or moving parts to limit life. "MAG MOD" Multipliers offer infinite design possibilities and impedance levels, and are adaptable for algebraic addition, subtraction, multiplying, dividing, raising to a power and vector summing. All "MAG MODS" conform to MIL-T-27A and MIL-E-5400 Specifications.



THERE IS NO SUBSTITUTE FOR RELIABILITY

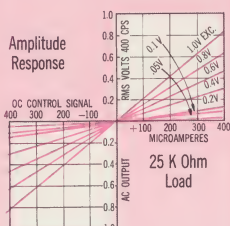
"MAG MOD"® *miniaturized* MULTIPLYING

ELECTRICAL AND MECHANICAL SPECIFICATIONS FOR

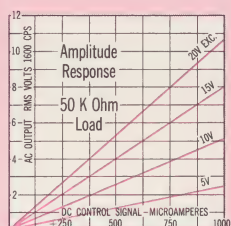
- Absolute reliability
- Unlimited life
- Repeatable data over years of continuous, unattended operation
- High shock and vibration proof
- Low milliwatt power consumption
- Bandwidth may be extended to the kilocycle range
- Four quadrant operation
- Extreme stability with negligible change of product accuracy over a wide temperature range
- Simple, lightweight, rugged
- May be mounted directly on printed circuit cards



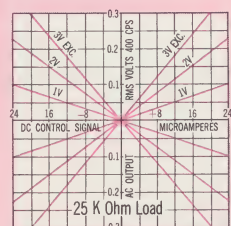
Multiplying Magnetic Modulator Type MCM-515-1



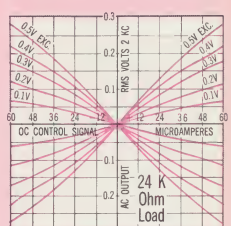
Multiplying Magnetic Modulator Type MCM-547-4



Multiplying Magnetic Modulator Type MCM-594-1

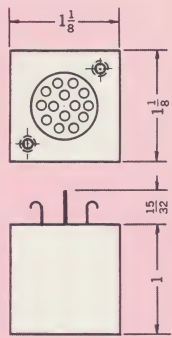
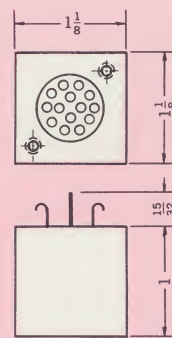
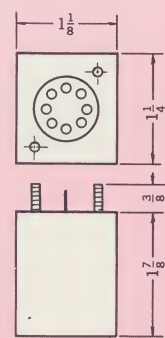
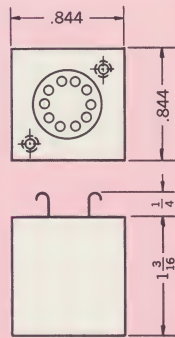


Multiplying Magnetic Modulator Type MCM-602-2



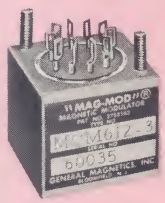
TYPE NUMBER	MCM-515-1	MCM-547-4	MCM-594-1	MCM-602-2
Product Accuracy (% Error of Theoretical Product)	5%	5%	4%	5%
Input Control Signal Range	0 to $\pm 400 \mu\text{A}$ DC	0 to $\pm 1000 \mu\text{A}$ DC	2 DC Signal Windings 0 to $\pm 24 \mu\text{A}$ DC each	2 DC Signal Windings 0 to $\pm 1.5 \text{ V}$ DC each
DC Resistance of Input DC Signal Winding	2600 ohms	7750 ohms	2 Windings 6200 ohms each	2 Windings 3200 ohms each
Input AC Signal Range Amplitude and Frequency (Carrier Excitation)	0 to 1.0 V RMS @ 400 cps	0 to 20 V RMS @ 1600 cps	2 AC Signal Windings 0 to 3.0 V RMS each @ 400 cps	2 AC Signal Windings 0 to 0.5 V RMS each @ 2000 cps
AC Output Product Range (Suppressed Carrier AM Envelope)	0 to 800 mv RMS @ 400 cps	0 to 10 V RMS @ 1600 cps	0 to 300 mv RMS @ 400 cps	0 to 250 mv RMS @ 2000 cps
Null Amplitude RMS mv (Noise Level at Max. AC Input Signal Level and Zero DC Signal Input)	5 mv RMS Maximum	50 mv RMS Maximum	2 mv RMS Maximum	2 mv RMS Maximum
Output Impedance	3500 ohms	15 K ohms	90 K ohms	18 K ohms
External Load	25 K ohms	50 K ohms	25 K ohms	24 K ohms
Temperature Range	-65°C to $+125^\circ\text{C}$	-55° to $+100^\circ\text{C}$	-55°C to $+100^\circ\text{C}$	-55°C to $+85^\circ\text{C}$
Null (Zero Point) Drift over Temp. Range in Terms of Percent of Maximum DC Input Signal	0.25% Maximum	0.25% Maximum	0.2% Maximum	0.1% Maximum
Approx. Percent Variation of Product Accuracy over Temperature Range	$\pm 1\%$	$\pm 1.25\%$	$\pm 0.5\%$	$\pm 0.5\%$
Hysteresis in Percent of Maximum Input DC Signal	0.2% Maximum	0.2% Maximum	0.1% Maximum	0.1% Maximum
Percent Harmonic Distortion in Output Product Wave	5%	10% Maximum	5% Maximum	3%
Overall Dimensions (in Inches)	$0.844 \times 0.844 \times 1\frac{1}{16}$	$1\frac{1}{8} \times 1\frac{1}{4} \times 1\frac{1}{8}$	$1\frac{1}{8} \times 1\frac{1}{8} \times 1$	$1\frac{1}{8} \times 1\frac{1}{8} \times 1$
Type of Mounting	Two 4-40 Inserts	Two 4-40 Studs	Two 4-40 Inserts	Two 4-40 Inserts
Approximate Weight (in Ounces)	0.85	4	1.1	1

Specify "MAG MOD" for proven reliability in solid state amplitude module applications. These dependable instruments are widely employed in automatic flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas and thousands of control systems. Micro-circuit, miniature, subminiature, standard, specials available.

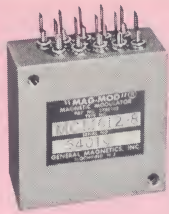
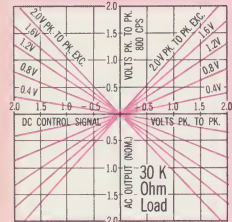


MAGNETIC MODULATORS

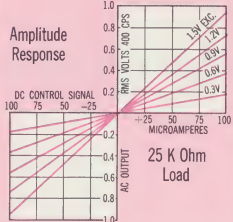
CONFORM TO MIL-T-27A AND
MIL-E-5400 SPECIFICATIONS



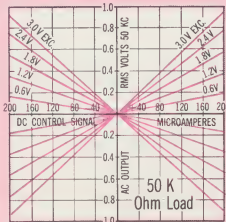
Multiplying
Magnetic Modulator
Type MCM-612-3



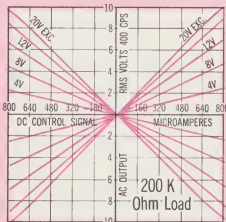
Multiplying
Magnetic Modulator
Type MCM-612-8



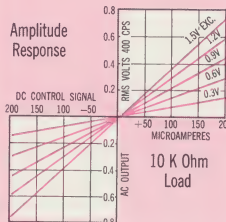
Multiplying
Magnetic Modulator
Type MCM-624-1



Multiplying
Magnetic Modulator
Type MCM-634-2

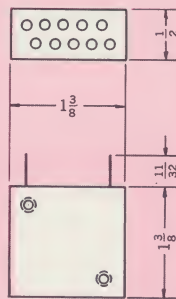
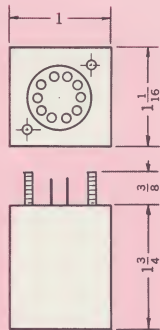
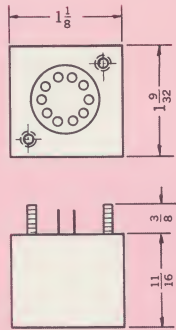
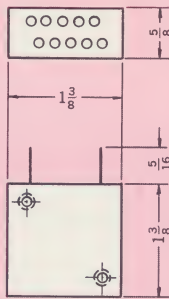
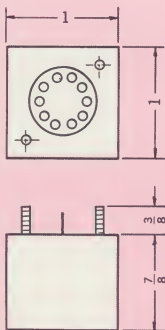


Multiplying
Magnetic Modulator
Type MCM-660-2



REFER TO
BACK PAGE
FOR BULLETINS
ON OTHER
"MAG MOD"
MAGNETIC
MODULATORS
AND HIGH
STABILITY
OSCILLATORS

MCM-612-3	MCM-612-8	MCM-624-1	MCM-634-2	MCM-660-2
2.5%	2%	3%	2.5%	2%
0 to ± 12 V DC	0 to ± 100 μ A DC	0 to ± 200 μ A DC	0 to ± 800 μ A DC	0 to ± 200 μ A DC
42 K ohms	2800 ohms	700 ohms	21 ohms	3 K ohms
0 to 1.0 V RMS @ 1 KC to 1.2 KC	0 to 1.5 V RMS @ 400 cps	0.3 to 3.0 V RMS @ 50 KC	0 to 20 V RMS @ 400 cps	0 to 1.5 V RMS @ 400 cps
0 to 1.2 V RMS @ 1 KC to 1.2 KC	0 to 1.0 V RMS @ 400 cps	0 to 1.0 V RMS @ 50 KC	0 to 10 V RMS @ 400 cps	0 to 800 mv RMS @ 400 cps
5 mv RMS Maximum	5 mv RMS Maximum	5 mv RMS Maximum	25 to 50 mv RMS Maximum	5 mv RMS Maximum
6800 ohms	10 K ohms	9 K ohms	9 K ohms	2 K ohms
10 K ohms	25 K ohms	50 K ohms	200 K ohms	10 K ohms
-55°C to +100°C	-55°C to +85°C	-30°C to +85°C	-55°C to +85°C	-55°C to +85°C
0.15% Maximum	0.2% Maximum	0.2%	0.2%	0.1%
$\pm 0.5\%$	$\pm 0.5\%$	$\pm 0.5\%$	$\pm 0.5\%$	$\pm 0.5\%$
0.1% Maximum	0.1% Maximum	0.1% Maximum	0.1% Maximum	0.1% Maximum
Less than 5%	Less than 5 %	Less than 3%	5%	5% Approx.
1 x 1 x 1	$\frac{5}{8}$ x $1\frac{3}{8}$ x $1\frac{3}{8}$	$1\frac{1}{32}$ x $1\frac{1}{8}$ x $1\frac{1}{16}$	1 x $1\frac{1}{16}$ x $1\frac{3}{4}$	$\frac{1}{2}$ x $1\frac{3}{8}$ x $1\frac{3}{8}$
Two 4-40 Studs	Two 4-40 Inserts	Two 4-40 Studs	Two 4-40 Studs	Two 4-40 Inserts
1	1.1	1.1	4	1



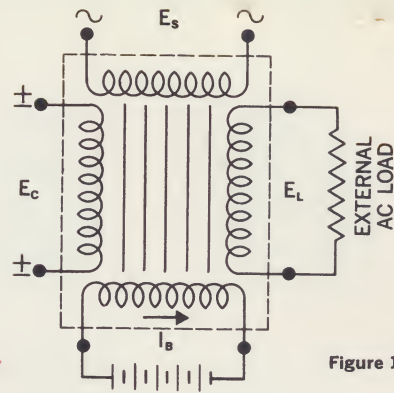


Figure 1

"MAG MOD"

MAGNETIC MULTIPLIERS

The MAGNETIC MULTIPLIER is a miniaturized magnetic modulator specifically designed to deliver an analog output voltage which is the continuous product of two variable input voltages. One of these is an excitation voltage which varies over a pre-determined range. The other signal is a variable bi-polar DC current which also varies over a predetermined range. The output voltage is an AC, which is always in phase or 180° out of phase with the variable excitation or fixed reference, i.e., in phase when the variable amplitude DC signal is positive, and 180° out of phase when the variable amplitude DC signal is negative. The general schematic is illustrated in Fig. 1. The relationship between variable alternating supply signal voltage E_s , variable direct current control signal E_c , and the alternating load voltage E_L having a sinusoidal wave shape is denoted by the equation

$$E_L = \text{Constant} \times E_s \times E_c.$$

This expression, which defines the fundamental principle of the four quadrant MAGNETIC MULTIPLYING MODULATOR, can be clearly illustrated by linear transfer response curve families as shown at right, in Figure 2-A and Figure 2-B.

Illustrating:

- (1) Load voltage E_L as a function of alternating supply signal voltage E_s with control DC signal voltage E_c as a parameter.
- (2) Load voltage E_L as a function of control DC signal voltage E_c with alternating supply signal voltage, E_s as a parameter.

With linearity response curves held to within approximately 1 to 2% of theoretical straight lines, the product accuracy of the fundamental equation will be within 2 to 5% of the theoretical product.

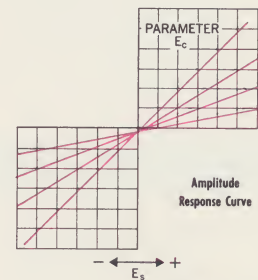


Figure 2-A

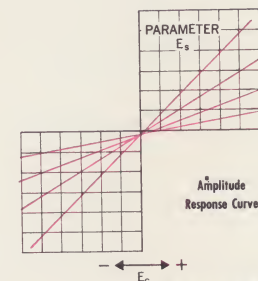


Figure 2-B



General Magnetics maintains extensive laboratory facilities for research and development

Custom Requirements — Customized application engineering, whenever required, will be performed on a no charge basis.



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